U.S. Department
of Transportation
**Federal Aviation
Administration**

Advisory Circular

Subject: Change 1 to FLIGHT TEST GUIDE FOR CERTIFICATION OF TRANSPORT CATEGORY AIRPLANES	**Date:** 6/6/95 **Initiated by:** ANM-110	**AC No:** AC 25-7 **Change:** 1

1. PURPOSE. This change provides updated guidance to ensure consistent application of certain airworthiness requirements recently adopted by Amendment 25-84.

Changed material is indicated in the margins by astericks. Some text, although not changed, has been rearranged to accommodate new material.

PAGE CONTROL CHART

Remove Pages	Dated	Insert Pages	Dated
225 and 226	4/9/86	225 and 226	6/6/95
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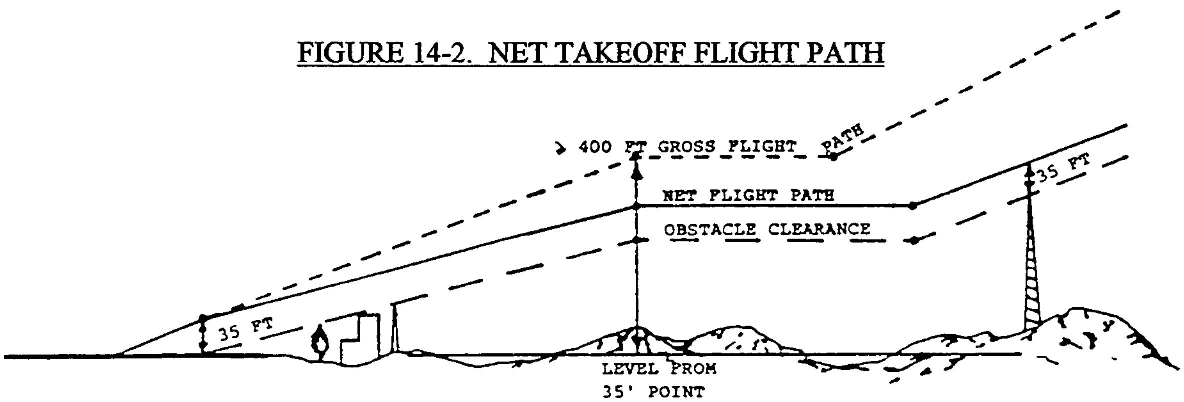
(ii) For the level flight acceleration segment, these prescribed gradient reductions may be applied as an equivalent reduction in acceleration in lieu of reduction in net flight path. See paragraph 12 (§ 25.111) of this AC for additional discussion.

(iii) SR-422B and § 121.189(d)(1) require that no airplane may take off at a weight in excess of that shown in the AFM to correspond with a net takeoff flight path which clears all obstacles, either by at least a height of 35 ft. vertically or by at least 200 ft. horizontally within the airport boundaries, and by at least 300 ft. horizontally after passing beyond the boundaries.

(2) Procedures.

FIGURE 14-2. NET TAKEOFF FLIGHT PATH



15. [RESERVED]

16. LANDING CLIMB: ALL-ENGINES-OPERATING - § 25.119.

* a. Explanation. Section 25.119(a) states that the engines are to be set at the power or thrust that is available eight seconds after initiating movement of the power or thrust controls from the minimum flight idle position to the go-around power or thrust setting. The procedures given are for the determination of this maximum thrust for showing compliance with the climb requirements of § 25.119. *

b. Procedures.

(1) Trim engines to minimum trim to be defined in the airplane maintenance manual.

(2) At the most adverse test altitude, not to exceed the maximum field elevation for which certification is sought plus 1,500 ft., and at the most adverse bleed configuration expected in normal operations, stabilize the airplane in level flight with symmetrical power on all engines, landing gear down, flaps in the landing position, at a speed of $1.3V_{SO}$. Retard the throttle(s) of the test engine(s) to flight idle and determine the time to reach stabilized r.p.m.,as defined below, for the test engine(s) while maintaining level flight or the minimum rate of descent obtainable with the thrust of the remaining engine(s) not greater than maximum continuous thrust (MCT). Engine flight idle r.p.m. is considered to be stabilized when the initial rapid deceleration of all rotors is completed. This has usually been 8-20 seconds. This can be determined in the cockpit as the point where rapid movement of the tachometer ceases. For some airplanes it may be desirable to determine the deceleration time from plots of r.p.m. versus time.

* (3) For the critical air bleed configuration, stabilize the airplane in level flight with symmetric power on all engines, landing gear down, flaps in the landing position, at a speed of 1.3 V_{S0}, simulating the estimated minimum climb limiting landing weights at an altitude sufficiently above the selected test altitude so that the time to descend to the test altitude with the throttles closed equals the appropriate engine r.p.m. stabilization time determined in paragraph (2). Retard the throttles to the flight idle position and descend at 1.3 V_S to approximately the test altitude; when the appropriate time has elapsed, rapidly advance the power or thrust controls to the go-around power or thrust setting. The power or thrust controls may first be advanced to the forward stop and then retarded to the go-around power or thrust setting. At the applicant's option, additional less critical bleed configurations may be tested. *

(4) The thrust that is available 8 seconds after the initiation of movement of the power or thrust controls from the minimum flight idle position, in accordance with paragraph (3), will be the maximum permitted for showing compliance with the landing climb of § 25.119(a), and Section 4T.119(a) of SR-422B for each of the bleed combinations tested under paragraph (3). If AFM performance is presented so there is no accountability for various bleed conditions, the thrust obtained with the most critical airbleed shall be used for landing climb performance for all operations. The effects of anti-ice bleed must be accounted for.

17. CLIMB: ONE-ENGINE-INOPERATIVE - § 25.121.

a. Explanation. None.

b. Procedures.

(1) Two methods for establishing the one critical-engine-inoperative climb performance follow:

(i) Reciprocal heading climbs are conducted at several thrust-to-weight conditions from which the performance for the AFM is extracted. These climbs are flown with the wings nominally level. Reciprocal climbs may not be necessary if inertial corrections are applied to account for wind gradients.

(ii) Drag polars and engine-out yaw drag data are obtained for expansion into AFM climb performance. These data are obtained with the wings nominally level. Reciprocal heading check climbs are conducted to verify the predicted climb performance. These check climbs may be flown with the wings maintained in a near level attitude. Reciprocal climbs may not be necessary if inertial corrections are applied to account for wind gradients.

(2) If full rudder with wings level cannot maintain constant heading, small bank angles into the operating engine(s), with full rudder, should be used

Section 3. CONTROLLABILITY AND MANEUVERABILITY

20. GENERAL - § 25.143.

a. Explanation. The purpose of § 25.143 is to verify that any operational maneuvers conducted within the operational envelope can be accomplished smoothly with average piloting skill and without exceeding any airplane structural limits. Control forces should not be so high that the pilot cannot safely maneuver the airplane. Also, the forces should not be so light it would take exceptional skill to maneuver the airplane without overstressing it or losing control. The airplane response to any control input should be predictable to the pilot.

* (1) The maximum forces given in the table in § 25.143(c) for pitch and roll control for short term application are applicable to maneuvers in which the control force is only needed for a short period. Where the maneuver is such that the pilot will need to use one hand to operate other controls (such as during the landing flare or a go-around, or during changes of configuration or power resulting in a change of control force that must be trimmed out) the single-handed maximum control forces will be applicable. In other cases (such as takeoff rotation, or maneuvering during en route flight), the two-handed maximum forces will apply.

(2) Short term and long term forces should be interpreted as follows:

(i) Short term forces are the initial stabilized control forces that result from maintaining the intended flight path following configuration changes and normal transitions from one flight condition to another, or from regaining control following a failure. It is assumed that the pilot will take immediate action to reduce or eliminate such forces by re-trimming or changing configuration or flight conditions, and consequently short term forces are not considered to exist for any significant duration. They do not include transient force peaks that may occur during the configuration change, change of flight conditions, or recovery of control following a failure.

(ii) Long term forces are those control forces that result from normal or failure conditions that cannot readily be trimmed out or eliminated. *

b. The applicable regulation is § 25.143.

c. Procedures. Compliance with § 25.143 is primarily a qualitative determination by the pilot during the course of the flight test program. The control forces required and airplane response should be evaluated during changes from one flight condition to another and during maneuvering flight. The forces required should be compatible for each flight condition evaluated. For example,during an approach for landing, the forces should be light and the airplane responsive in order that adjustments in the flight path can be accomplished with a minimum of workload. In cruise flight, forces and airplane response should be such that inadvertent control input does not result in exceeding limits or in undesirable maneuvers. Longitudinal control forces should be evaluated during accelerated flight to ensure a positive stick force with increasing normal acceleration. Forces should be heavy enough at the limit load factor to prevent inadvertent excursions beyond design limit. Sudden engine failures should be investigated during any flight condition or in any configuration considered critical, if not covered by another Section of Part 25. Control forces considered excessive should be measured to show compliance with § 25.143(c), "strength of pilots" limits. Allowance should be made for delays in the initiation of recovery action appropriate to the situation.

* d. Acceptable Means of Compliance. An acceptable means of compliance with the requirement that stick forces may not be excessive when maneuvering the airplane is to demonstrate that, in a turn for 0.5g incremental normal acceleration (0.3g above 20,000 feet) at speeds up to V_{FC}/M_{FC}, the average stick force gradient does not exceed 120 pounds/g.

e. Interpretive Material.

(1) The objective of § 25.143(f) is to ensure that the limit strength of any critical component on the airplane would not be exceeded in maneuvering flight. In much of the structure, the load sustained in maneuvering flight can be assumed to be directly proportional to the load factor applied. However, this may not be the case for some parts of the structure (e.g., the tail and rear fuselage). Nevertheless, it is accepted that the airplane load factor will be a sufficient guide to the possibility of exceeding limit strength on any critical component if a structural investigation is undertaken whenever the design positive limit maneuvering load factor is closely approached. If flight testing indicates that the design positive limit maneuvering load factor could be exceeded in steady maneuvering flight with a 50 pound stick force, the airplane structure should be evaluated for the anticipated load at a 50 pound stick force. The airplane will be considered to have been overstressed if limit strength has been exceeded in any critical component. For the purposes of this evaluation, limit strength is defined as the larger of either the limit design loads envelope increased by the available margins of safety, or the ultimate static test strength divided by 1.5.

(2) Minimum Stick Force to Reach Limit Strength.

(i) A stick force of at least 50 pounds to reach limit strength in steady maneuvers or wind-up turns is considered acceptable to demonstrate adequate minimum force at limit strength in the absence of deterrent buffeting. If heavy buffeting occurs before the limit strength condition is reached, a somewhat lower stick force at limit strength may be acceptable. The acceptability of a stick force of less than 50 pounds at the limit strength condition will depend upon the intensity of the buffet, the adequacy of the warning margin (i.e., the load factor increment between the heavy buffet and the limit strength condition), and the stick force characteristics. In determining the limit strength condition for each critical component, the contribution of buffet loads to the overall maneuvering loads should be taken into account.

(ii) This minimum stick force applies in the en route configuration with the airplane trimmed for straight flight, at all speeds above the minimum speed at which the limit strength condition can be achieved without stalling. No minimum stick force is specified for other configurations, but the requirements of § 25.143(f) are applicable in these conditions.

(3) Stick Force Characteristics. *

* (i) At all points within the buffet onset boundary determined in accordance with § 25.251(e), but not including speeds above V_{FC}/M_{FC}, the stick force should increase progressively with increasing load factor. Any reduction in stick force gradient with change of load factor should not be so large or abrupt as to impair significantly the ability of the pilot to maintain control over the load factor and pitch attitude of the airplane.

(ii) Beyond the buffet onset boundary, hazardous stick force characteristics should not be encountered within the permitted maneuvering envelope as limited by paragraph 20e(3)(iii). It should be possible, by use of the primary longitudinal control alone, to pitch the airplane rapidly nose down so as to regain the initial trimmed conditions. The stick force characteristics demonstrated should comply with the following:

(A) For normal acceleration increments of up to 0.3g beyond buffet onset, where these can be achieved, local reversal of the stick force gradient may be acceptable, provided that any tendency to pitch up is mild and easily controllable.

(B) For normal acceleration increments of more than 0.3g beyond buffet onset, where these can be achieved, more marked reversals of the stick force gradient may be acceptable. It should be possible for any tendency to pitch up to be contained within the allowable maneuvering limits without applying push forces to the control column and without making a large and rapid forward movement of the control column.

(iii) In flight tests to satisfy paragraphs 20e(3)(i) and (ii), the load factor should be increased until either:

(A) The level of buffet becomes sufficient to provide a strong and effective deterrent to further increase of load factor; or

(B) Further increase of load factor requires a stick force in excess of 150 pounds (or in excess of 100 pounds when beyond the buffet onset boundary) or is impossible because of the limitations of the control system; or

(C) The positive limit maneuvering load factor established in compliance with § 25.337(b) is achieved.

(4) Negative Load Factors. It is not intended that a detailed flight test assessment of the maneuvering characteristics under negative load factors should necessarily be made throughout the specified range of conditions. An assessment of the characteristics in the normal flight envelope involving normal accelerations from 1g to zero g will normally be sufficient. Stick forces should also be assessed during other required flight testing involving negative load factors. Where these assessments reveal stick force gradients that are unusually low, or that are subject to significant variation, a more detailed assessment, in the most critical of the specified conditions, will be required. This may be based on calculations, provided these are supported by adequate flight test or wind tunnel data. *

21. LONGITUDINAL CONTROL - § 25.145.

a. Explanation.

(1) Section 25.145(a) requires that there be adequate longitudinal control to promptly pitch the airplane nose down from, at, or near the stall to return to the original trim speed. The intent is to insure sufficient pitch control if inadvertently slowed to the point of stall.

(2) Section 25.145(b) requires changes to be made in flap position, power, and speed without undue effort when retrimming is not practical. The purpose is to insure that any of these changes are possible assuming that the pilot finds it necessary to devote at least one hand to the initiation of the desired operation without being overpowered by the primary airplane controls. The objective is that no excessive change in trim will result from the application or removal of power or the extension or retraction of wing flaps. Compliance with its terms also requires that the relation of control force to speed be such that reasonable changes in speed may be made without encountering very high control forces.

* (3) Section 25.145(c) contains requirements associated primarily with attempting a go-around maneuver from the landing configuration. Retraction of the high-lift devices from the landing configuration should not result in a loss of altitude if the power or thrust controls are moved to the go-around setting at the same time that flap/slat retraction is begun. The design features involved with this requirement are the rate of flap/slat retraction, the presence of any flap gates, and the go-around power or thrust setting.

(i) Flap gates, which prevent the pilot from moving the flap selector through the gated position without a separate and distinct movement of the selector, allow compliance with these requirements to be demonstrated in segments. High lift device retraction must be demonstrated beginning from the maximum landing position to the first gated position, between gated positions, and from the last gated position to the fully retracted position.

(ii) The go-around power or thrust setting should be the same as is used to comply with the approach and landing climb performance requirements of §§ 25.121(d) and 25.119, and the controllability requirements of §§ 25.145(b)(3), 25.145(b)(4), 25.145(b)(5), 25.149(f), and 25.149(g). The controllability requirements may limit the go-around power or thrust setting. *

b. The applicable regulations are §§ 25.145(a),(b), and (c) of the FAR.

c. Procedures. The following test procedures outline an acceptable means for demonstrating compliance with § 25.145. These tests may be conducted at an optional altitude in accordance with § 25.21(c). Where applicable, the conditions should be maintained on the engines throughout the maneuver.

(l) Longitudinal control recovery, § 25.145(a):

(i) Configuration:

(A) Maximum weight or a lighter weight if considered more critical.

(B) Aft c.g. position.

(C) Landing gear extended.

(D) Wing flaps retracted and extended to the maximum landing position.

(E) Engine power at idle and maximum continuous.

(ii) Test procedure: The airplane should be trimmed at the speed for each configuration as prescribed in § 25.103(b)(1). The nose should be pitched downward from any speed between V trim and the stall. In past programs the most critical point has been at the stall when in stall buffet. The rate of speed increase should be adequate to promptly return to the trim point. Data from the stall characteristics test could be used to evaluate this condition at the stall.

(2) Longitudinal control, flap extension, § 25.145(b)(1).

(i) Configuration:

(A) Maximum landing weight.

(B) Critical c.g. position.

(C) Wing flaps retracted.

(D) Landing gear extended.

(E) Engine power at flight idle.

(ii) Test procedure: The airplane should be trimmed at a speed of $1.4V_S$. The flaps should be extended to the maximum landing position as rapidly as possible while maintaining approximately $1.4V_S$ for the flap position existing at each instant throughout the maneuver. The control forces should not exceed 50 pounds (the maximum temporary forces that can be applied readily by one hand) throughout the maneuver without changing the trim control.

(3) Longitudinal control, flap retraction, §§ 25.145(b)(2) & (3).

(i) Configuration:

(A) Maximum landing weight.

(B) Critical c.g. position.

(C) Wing flaps extended to maximum landing position.

(D) Landing gear extended.

* (E) Engine power at flight idle and the go-around power or thrust setting. *

(ii) With the airplane trimmed at $1.4V_S$, the flaps should be retracted to the full up position while maintaining approximately $1.4V_S$ for the flap position existing at each instant throughout the maneuver. The longitudinal control force should not exceed 50 pounds throughout the maneuver without changing the trim control.

(4) Longitudinal control, power application, §§ 25.145(b)(4) & (5).

(i) Configuration:

(A) Maximum landing weight.

(B) Critical c.g. position.

(C) Wing flaps retracted and extended to the maximum landing position.

(D) Landing gear extended.

(E) Engine power at flight idle.

* (ii) The airplane should be trimmed at a speed of $1.4\ V_S$. Quickly set go-around power or thrust while maintaining the speed of $1.4\ V_S$. The longitudinal control force should not exceed 50 pounds throughout the maneuver without changing the trim control. *

(5) Longitudinal control, airspeed variation, § 25.145(b)(6).

(i) Configuration:

(A) Maximum landing weight.

(B) Most forward c.g. position.

(C) Wing flaps extended to the maximum landing position.

(D) Landing gear extended.

(E) Engine power at flight idle.

(ii) Test Procedure: The airplane should be trimmed at a speed of $1.4V_S$. The speed should then be reduced to $1.1V_S$ and then increased to $1.7V_S$, or the flap placard speed, V_{FE}, whichever is lower. The longitudinal control force should not be greater than 50 pounds. Data from the static longitudinal stability tests in the landing configuration at forward c.g., § 25.175(d), may be used to show compliance with this requirement.

(6) Longitudinal control, flap retraction and power application, § 25.145(c).

(i) Configuration:

(A) Critical combinations of maximum landing weights and altitudes.

(B) Critical c.g. position.

(C) Wing flaps extended to the maximum landing position and gated position, if applicable.

(D) Landing gear extended.

(E) Engine power for level flight at a speed of $1.1V_S$ for propeller driven airplanes, or $1.2V_S$ for turbojet powered airplanes.

* (ii) Test procedure: With the airplane stable in level flight at a speed of $1.1\ V_S$ for propeller driven airplanes, or $1.2\ V_S$ for turbojet powered airplanes, retract the flaps to the full up position, or the next gated position, while simultaneously setting go-around power. Use the same power or thrust as is used to comply with the performance requirement of § 25.121(d), as limited by the applicable controllability requirements. It must be possible, without requiring exceptional piloting skill, to prevent losing altitude during the maneuver. Trimming is permissible at any time during the maneuver. If gates are provided, conduct this test beginning from the maximum landing flap position to the first gate, from gate to gate, and from the last gate to the fully retracted position. (The gate design requirements are specified within the rule.) Keep the landing gear extended throughout the test. *

22. DIRECTIONAL AND LATERAL CONTROL - § 25.147.

a. Explanation.

(1) Sections 25.147(a) and (b) are intended to be investigated for dangerous characteristics such as rudder lock or loss of directional control with one or two critical engines inoperative. Sudden heading changes of up to 15 degrees are required unless the rudder force limit of 150 lbs. (180 pounds prior to Amendment 25-42) is reached. If the rudder reaches full travel without attaining 150 pounds force limit or a 15-degree heading change, satisfactory controllability must be demonstrated with this configuration for expected service operations. After full rudder is reached, heading changes using lateral control are permissible provided that no more than a 5-degree bank angle is required.

(2) Sections 25.147(a) and (b) are written to show an airplane will still be under control if yawed suddenly toward and against inoperative engine(s). Paragraphs (c) and (d) require an airplane to be easily controllable with critical inoperative engine(s). Roll response, § 25.147(e), should be satisfactory for takeoff, approach, landing, and high speed configurations. Any permissible configuration which could affect roll response should be evaluated.

b. Procedures.

(1) Directional Control - General, § 25.147(a).

(i) Configuration:

(A) Maximum landing weight.

(B) Most aft c.g. position.

(C) Wing flaps extended to the approach position.

(D) Landing gear retracted.

(E) Yaw SAS on, and off if applicable.

(F) Operating engine(s) at the power for level flight at $1.4V_S$, but not more than maximum continuous power.

(G) Inoperative engine that would be most critical for controllability, with propeller feathered, if applicable.

(ii) Test Procedure: The airplane should be trimmed in level flight at the most critical altitude in accordance with § 25.21(c). Reasonably sudden changes in heading to the left and right, using ailerons to maintain approximately wings level flight, should be made demonstrating a change up to 15 degrees or at which 150 pounds rudder force is required. The airplane should be controllable and free from any hazardous characteristics during this maneuver.

(2) Directional Control - Four or More Engines, § 25.147(b).

(i) Configuration:

(A) Maximum landing weight.

(B) Most forward c.g. position.

(C) Wing flaps in the most favorable climb position (normally retracted).

(D) Landing gear retracted.

(E) Yaw SAS on, and off if applicable.

(F) Operating engines at the power required for level flight at $1.4V_{S1}$, but not more than maximum continuous power.

(G) Two inoperative engines that would be more critical for controllability with (if applicable) propellers feathered.

(ii) Test Procedure: The procedure outlined in subparagraph b(1)(ii) above is applicable to this test.

(3) Lateral Control - General, § 25.147(c).

(i) Configuration:

(A) Maximum takeoff weight.

(B) Most aft c.g. position.

(C) Wing flaps in the most favorable climb position.

(D) Landing gear retracted and extended.

(E) Yaw SAS on, and off if applicable.

(F) Operating engine(s) at maximum continuous power.

(G) The inoperative engine that would be most critical for controllability, with the propeller feathered, if applicable.

(ii) Test Procedure: With the airplane trimmed at $1.4V_S$, turns with a bank angle of 20 degrees should be demonstrated with and against the inoperative engine from a steady climb at $1.4V_{S1}$. It should not take exceptional piloting skill to make smooth, predictable turns.

(4) Lateral Control - Four or More Engines, § 25.147(d).

(i) Configuration:

(A) Maximum takeoff weight.

(B) Most aft c.g. position.

(C) Wing flaps in the most favorable climb position.

(D) Landing gear retracted and extended.

(E) Yaw SAS on, and off if applicable.

(F) Operating engines at maximum continuous power.

(G) Two inoperative engines most critical for controllability, with propellers feathered, if applicable.

(ii) Test Procedure: The procedure outlined in subparagraph b(3)(ii) is applicable to this test.

(5) Lateral Control - All Engines Operating, § 25.147(e).

(i) Configuration: All configurations within the flight envelope for normal operation.

(ii) Test Procedure: This is primarily a qualitative evaluation which should be conducted throughout the test program. Roll performance should be investigated throughout the flight envelope, including speeds to V_{FC}/M_{FC}, to ensure adequate peak roll rates for safety, considering the flight condition, without excessive control force or travel. Roll response during sideslips expected in service should provide enough maneuvering capabilities adequate to recover from such conditions. Approach and landing configurations should be carefully evaluated to ensure adequate control to compensate for gusts and wake turbulence while in close proximity to the ground.

23. MINIMUM CONTROL SPEED - § 25.149.

* a. Explanation. Section 25.149 defines requirements for minimum control speeds during takeoff climb (V_{MC}), during takeoff ground roll (V_{MCG}), and during approach and landing (V_{MCL} and V_{MCL-2}). The V_{MC} (commonly referred to as V_{MCA}) requirements are specified in §§ 25.149(a), (b), (c) and (d); the V_{MCG} requirements are described in § 25.149(e); and the V_{MCL} and V_{MCL-2} requirements * are covered in §§ 25.149(f), (g) and (h). Section 25.149(a) states that the method used to simulate critical engine failure must represent the most critical mode of powerplant failure with respect to controllability in service. That is, the thrust loss from the inoperative engine must be at the rate that would occur if an engine suddenly became inoperative in service. Prior to Amendment 25-42 to § 25.149, the regulation required that rudder control forces must not exceed 180 pounds. Amendment 25-42 limits rudder control forces to 150 pounds. The relationship between V_{EF}, V_1, and V_{MCG}, including the requirements applicable prior to Amendment 25-42, is discussed in paragraph 10, Takeoff and Takeoff Speeds, and paragraph 11, Accelerate-Stop Distance.

b. Procedures.

(1) Minimum Control Speeds - Air (V_{MCA}).

(i) To comply with the V_{MCA} requirements, the following two conditions must be satisfied: (Separate tests are usually conducted to show compliance with these two requirements.)

(A) The dynamic condition in which control is maintained without exceeding a heading change of 20 degrees.

(B) The stabilized (static) condition where constant heading is maintained without exceeding a 5 degree bank angle.

(ii) Static Test Procedure and Required Data. After establishing the critical inoperative engine, the tests for establishing the minimum control speed may be conducted. Using the configuration specified in § 25.149 with the critical engine inoperative, the remaining engine(s) will be adjusted to maximum takeoff power and/or thrust; the airspeed will be decreased until one of the limiting factors specified in § 25.149(b), (c) or (d) is experienced. For airplanes with more than two engines, the inboard engine(s) may be throttled, provided the appropriate yawing moment coefficient (C_N) is maintained. If the maximum power and/or thrust within the approved airplane operating envelope was maintained to the minimum test speed, this speed may be used as the V_{MCA} for the airplane. If, at the option of the applicant, V_{MCA} is to vary with altitude and temperature, the minimum test speed and corresponding thrust may be reduced to an equivalent C_N. From this C_N, V_{MCA} may be calculated to vary with takeoff thrust. If maximum takeoff thrust could not be achieved during this test, the C_N can be used to calculate the V_{MCA} for maximum takeoff thrust. It has been acceptable to extend the thrust 5 percent beyond the test thrust. If V_{MCA} is near or less than V_S for the test airplane, consideration may be given to conducting the test at a more extended flap position. It should be noted, however, that a more extended flap position may produce unconservative results. In the event V_{MCA} is less than stall speed at all usable operational gross weights, demonstration that shows compliance with the V_{MCA} requirements may be shown as follows:

(A) Conduct static V_{MCA} tests using partial rudder deflections to achieve a variation in C_N with rudder deflection.

(B) Plot the asymmetric thrust yawing moment (C_N) versus control surface deflection (lateral and directional). These plots should be faired and then extrapolated to full control surface deflections. Plot C_N versus rudder pedal force. This plot should be faired to 150 pounds (180 pounds prior to Amendment 25-42). Whichever condition of the three is most limiting determines the maximum C_N from which V_{MCA} can be calculated.

(C) The extrapolation should be limited to 5 percent of the yawing moment coefficient unless a rigorous analysis is made to account for all of the stability and control terms.

(D) Compute the stalling speed (V_S) at the airplane Operational Weight Empty (OWE) for the maximum takeoff flap position and compute V_{MCA} from C_N using the maximum asymmetric takeoff thrust. If the computed V_{MCA} is less than V_S, then the airplane is stall limited and V_{MCA} is not a factor.

(iii) Dynamic Test Procedure and Required Data. In addition to the static test procedure, dynamic demonstrations should be made to provide adequate proof that the speed(s) determined also meet the dynamic requirements. The dynamic demonstration is conducted by applying the maximum rated power and/or thrust to all engines and suddenly cutting the critical engine. It should be possible to recover to a constant heading without exceeding the requirements of § 25.149(d). If the thrust/weight for the dynamic demonstration produces an extreme nose-high attitude, normally more than 20 degrees, another method should be used such as conducting dynamic demonstrations using a minimum required rudder and aileron control at reduced thrust and comparing control deflection and force required between the dynamic demonstration and static demonstration at several reduced thrust conditions.

(iv) If V_{MCA} has been shown to be less than V_S by the static method, the dynamic demonstration may be conducted at speeds such as $1.1V_S$ and evaluated in accordance with paragraph (iii) above.

(v) Normally, V_{MCA} and V_{MCG} will be determined by rendering the engine inoperative and allowing the propeller to autofeather; however, on some airplanes a more critical drag condition can be produced during a partial power condition. Some engine propeller combinations might be subject to this type of failure. One example is some turbopropeller installations can have a fuel control failure that causes the engine to go to flight idle, resulting in a higher asymmetric drag than that obtained from an inoperative engine. In such a case, the test must be conducted in the most critical condition.

(vi) There may be some difference between right and left engine inoperative V_{MCA} due to propeller slip stream rotation reducing rudder effectiveness to maintain the airplane on its original heading. The critical engine should be determined and the V_{MCA} for that configuration should be used.

(vii) V_{MCA} and V_{MCG} should be based on the maximum net thrust reasonably expected for a production engine. These speeds should not be based on specification thrust since this thrust represents the minimum thrust as guaranteed by the engine manufacturer, and the resulting speeds could be too slow. The thrust used for scheduled V_{MCA} and V_{MCG} speeds should represent the high side of the tolerance band and may be determined by analysis instead of tests.

(2) Minimum Control Speed - Ground (V_{MCG}) - § 25.149(e).

(i) It must be demonstrated that, when the critical engine is suddenly made inoperative at V_{MCG} during the takeoff ground roll, the airplane is safely controllable to continue the takeoff. During the demonstration, the airplane must not deviate more than 30 feet (25 feet prior to Amendment 25-42) from the pre-engine-cut projected ground track. The critical engine is determined by the methods as described above under § 25.149(c).

(ii) Tests may be conducted by abruptly retarding the engine to idle to establish the target V_{MCG}. At least one fuel cut should be made at each maximum asymmetric thrust level desired to be certificated to investigate the more rapid thrust decay associated with this type of engine failure. At the applicant's option, in crosswind conditions, the runs may be made on reciprocal headings or an analytical correction may be applied to determine the zero crosswind value of V_{MCG}.

* (iii) During determination of V_{MCG}, engine failure recognition should be provided by:

(A) The pilot feeling a distinct change in the directional tracking characteristics of the airplane, or

(B) The pilot seeing a directional divergence of the airplane with respect to the view outside the airplane. *

(iv) Control of the airplane should be accomplished by use of the rudder only. All other controls, like ailerons and spoilers, should only be used to correct any alterations in the airplane attitude and to maintain a wings level condition. Use of those controls to supplement the rudder effectiveness should not be allowed.

(v) The V_{MCG} should be considered at the heaviest weight where V_{MCG} may impact the AFM V_1 schedule.

(vi) The test should be conducted at aft c.g. and with the nose wheel free to caster, to minimize the stabilizing effect of the nose gear.

(vii) For airplanes with certification basis prior to Amendment 25-42, V_{MCG} values may be demonstrated with nose wheel rudder pedal steering operative for dispatch on wet runways. The test should be conducted on an actual wet runway. The test(s) should include engine failure at or near a minimum V_{EF} associated with minimum V_R to demonstrate adequate controllability during rotation, liftoff, and the initial climbout. The V_{MCG} values obtained by this method are applicable for wet or dry runways only, not for icy runways.

* (3) <u>Minimum Control Speed During Approach and Landing (V_{MCL})- § 25.149(f)</u>.

(i) This section is intended to ensure that the airplane is safely controllable following an engine failure during an all-engines-operating approach and landing. From a controllability standpoint, the most critical case usually consists of an engine failing after the power or thrust has been increased to perform a go-around from an all-engines-operating approach. Section 25.149(f) requires the minimum control speed to be determined that allows a pilot of average skill and strength to retain control of the airplane after the critical engine becomes inoperative and to maintain straight flight with less than five degrees of bank angle. Section 25.149(h) requires that sufficient lateral control be available at V_{MCL} to *

* roll the airplane through an angle of 20 degrees, in the direction necessary to initiate a turn away from the inoperative engine, in not more than five seconds when starting from a steady straight flight condition.

(ii) Conduct this test using the most critical of the all-engines-operating approach and landing configurations, or at the option of the applicant, each of the all-engines-operating approach and landing configurations. The procedures given in paragraph 23b(1)(ii) for V_{MCA} may be used to determine V_{MCL}, except that flap and trim settings should be appropriate to the approach and landing configurations, the power or thrust on the operating engine(s) should be set to the go-around power or thrust setting, and compliance with all V_{MCL} requirements of §§ 25.149(f) and (h) must be demonstrated.

(iii) For propeller driven airplanes, the propeller must be in the position it achieves without pilot action following engine failure, assuming the engine fails while at the power or thrust necessary to maintain a three degree approach path angle.

(iv) At the option of the applicant, a one-engine-inoperative landing minimum control speed, $V_{MCL(1\ out)}$, may be determined in the conditions appropriate to an approach and landing with one engine having failed before the start of the approach. In this case, only those configurations recommended for use during an approach and landing with one engine inoperative need be considered. The propeller of the inoperative engine, if applicable, may be feathered throughout. The resulting value of $V_{MCL(1\ out)}$ may be used in determining the recommended procedures and speeds for a one-engine-inoperative approach and landing.

(4) Minimum Control Speed with One Engine Inoperative During Approach and Landing (V_{MCL-2}) - § 25.149(g). *

(i) For airplanes with three or more engines, V_{MCL-2} is the minimum speed for maintaining safe control during the power or thrust changes that are likely to be made following the failure of a second engine during an approach initiated with one engine inoperative.

* (ii) For propeller driven airplanes, the propeller of the engine inoperative at the beginning of the approach may be in the feathered position. The propeller of the more critical engine must be in the position it automatically assumes following engine failure.

(iii) Conduct this test using the most critical approved one-engine-inoperative approach or landing configuration (usually the minimum flap deflection), or at the option of the applicant, each of the approved one-engine-inoperative approach and landing configurations. The following demonstrations are required to determine V_{MCL-2}:

(A) With the power or thrust on the operating engines set to maintain a minus 3 degree glideslope with one critical engine inoperative, the second critical engine is made inoperative and the remaining operating engine(s) are advanced to the go-around power or thrust setting. The V_{MCL-2} speed is established by the procedures presented in paragraph 23b(1)(ii) for V_{MCA}, except that flap and trim settings should be appropriate to the approach and landing configurations, the power or *

* thrust on the operating engine(s) should be set to the go-around power or thrust setting, and compliance with all V_{MCL-2} requirements of §§ 25.149(g) and (h) must be demonstrated. *

(B) With power on the operating engines set to maintain a minus 3 degree glideslope, with one critical engine inoperative:

(1) Set the airspeed at the value determined above in step (A) and, with zero bank angle, maintain a constant heading using trim to reduce the control force to zero. If full trim is insufficient to reduce the control force to zero, full trim should be used plus control deflection as required; and

(2) Make the second critical engine inoperative and retard the remaining operating engine(s) to minimum available power without changing the directional trim. The V_{MCL-2} determined in paragraph (A) is acceptable if constant heading can be maintained without exceeding a 5 degree bank angle and the limiting conditions of § 25.149(h).

* (C) Starting from a steady straight flight condition, demonstrate that sufficient lateral control is available at V_{MCL-2} to roll the airplane through an angle of 20 degrees in the direction necessary to initiate a turn away from the inoperative engines in not more than five seconds. This maneuver may be flown in a bank-to-bank roll through a wings level attitude.

(iv) At the option of the applicant, a two-engines-inoperative landing minimum control speed, $V_{MCL-2(2\ out)}$, may be determined in the conditions appropriate to an approach and landing with two engines having failed before the start of the approach. In this case, only those configurations recommended for use during an approach and landing with two engines inoperative need be considered. The propellers of the inoperative engines, if applicable, may be feathered throughout. The values of V_{MCL-2} or $V_{MCL-2(2\ out)}$ should be used as guidance in determining the recommended procedures and speeds for a two-engines-inoperative approach and landing.

(5) Autofeather Effects. Where an autofeather or other drag limiting system is installed and will be operative at approach power settings, its operation may be assumed in determining the propeller position achieved when the engine fails. Where automatic feathering is not available, the effects of subsequent movements of the engine and propeller controls should be considered, including fully closing the power lever of the failed engine in conjunction with maintaining the go-around power setting on the operating engine(s). *

Section 6. STALLS

29. STALL TESTING.

a. The applicable Federal Aviation Regulations (FAR) are as follows:

Section 25.21(c)	Proof of Compliance
Section 25.103	Stalling Speed
Section 25.143	Controllability and Maneuverability (General)
Section 25.201	Stall Demonstration
Section 25.203	Stall Characteristics
Section 25.205	Stalls: Critical Engine Inoperative
Section 25.207	Stall Warning

b. Explanation.

(1) The purpose of stall testing is threefold:

(i) To define the minimum inflight airspeeds and how they vary with weight, altitude, and airplane configuration (stall speeds).

(ii) To demonstrate that handling qualities are adequate to allow a safe recovery from the highest angle-of-attack attainable in normal flight (stall characteristics).

(iii) To determine that there is adequate prestall warning (either aerodynamic or artificial) to allow the pilot time to recover from any probable high angle-of-attack condition without inadvertently stalling the airplane.

(2) During this testing, the angle-of-attack should be increased at least to the point where the following two conditions are satisfied:

(i) Attainment of an angle-of-attack measurably greater than that for maximum lift, except when the stall is defined by a stall prevention device (e.g., stick pusher).

(ii) Clear indication to the pilot through the inherent flight characteristics or stall prevention device (e.g., stick pusher) that the airplane is stalled.

(3) The airplane is considered to be fully stalled when any one or a combination of the below listed characteristics occurs to give the pilot a clear and distinctive indication that he should stop any further increase in angle of attack, at which time recovery should be initiated using normal techniques. The

stall speed is defined as the minimum speed reached during the maneuver, except for those airplanes which
* require stall prevention devices (see paragraph (iv) below).

(i) The pitch control reaches the aft stop and is held full aft for two seconds, or until the pitch attitude stops increasing, whichever occurs later. In the case of turning flight stalls, recovery may be initiated once the pitch control reaches the aft stop when accompanied by a rolling motion that is not immediately controllable (provided the rolling motion complies with § 25.203(c)).

(ii) An uncommanded, distinctive and easily recognizable nose down pitch that cannot be readily arrested. This nose down pitch may be accompanied by a rolling motion that is not immediately controllable, provided that the rolling motion complies with § 25.203(b) or (c) as appropriate.

(iii) The airplane demonstrates an unmistakable, inherent aerodynamic warning of a magnitude and severity that is a strong and effective deterrent to further speed reduction. This deterrent level of aerodynamic warning (i.e., buffet) must be of a much greater magnitude than the initial buffet ordinarily associated with stall warning. An example is a large transport airplane which exhibits "deterrent buffet" with flaps up and is characterized by an intensity which inhibits reading cockpit instruments and would require a strong determined effort by the pilot to increase the angle-of-attack any further.

(iv) The activation point of a stall prevention device which is a strong and effective deterrent to further speed reduction. If an artificial stall prevention system is used, stall speed may be defined as the minimum speed in the maneuver, provided stall characteristics are shown to be acceptable at an angle-of-attack at least 10 percent beyond the activation point of the stall prevention device. (See Figure 29-1.) *

(4) <u>It should be recognized</u> that the point at which the airplane is considered stalled may vary, depending on the airplane configuration (flaps, gear, drag devices, center of gravity, and gross weight). In any case, the angle-of-attack must be increased until one or more of these characteristics is reached for all likely combinations of variables.

c. <u>Stall Speeds</u>.

(1) <u>Background</u>. Since many of the regulations pertaining to performance and handling qualities specify trim speeds and other variables which are functions of stall speeds, it is desirable to accomplish the stall speed testing early in the program, so the data are available for subsequent testing. Because of this interrelationship between the stall speeds and other critical performance parameters, it is essential that accurate measurement methods be used. Most standard airplane pitot-static systems have not been found to be acceptable for stall speed determination. These tests require the use of properly calibrated instruments and usually require a separate test airspeed system, such as a trailing bomb, a trailing cone, or an acceptable nose or wing boom.

(3) Procedures.

* (i) The airplane should be trimmed for hands-off flight at a speed 20 percent to 40 percent above the stall speed, with the appropriate power setting and configuration. Then, using only the primary longitudinal control, establish and maintain a deceleration (entry rate) consistent with that specified in §§ 25.201(c)(1) or 25.201(c)(2), as appropriate, until the airplane is stalled. Both power and pilot selectable trim should remain constant throughout the stall and recovery (angle of attack has decreased to the point of no stall warning). *

(ii) The same trim reference (for example, $1.3V_S$) should be used for both the stall speeds and characteristics testing. For all stall testing, the trim speed is based on the performance stall speeds which are (or will be) shown in the AFM.

* (iii) In addition, for turning flight stalls, apply the longitudinal control to achieve airspeed deceleration rates up to 3 knots per second. The intent of evaluating higher deceleration rates is to demonstrate safe characteristics at higher rates of increase of angle of attack than are obtained from the 1 knot per second stalls. The specified airspeed deceleration rate, and associated angle of attack rate, should be maintained up to the point at which the airplane stalls.

(iv) For those airplanes where stall is defined by full nose-up longitudinal control for both forward and aft c.g., the time at full aft stick during characteristics testing should be not less than that used for stall speed determination. For turning flight stalls, however, recovery may be initiated once the pitch control reaches the aft stop when accompanied by a rolling motion that is not immediately controllable (provided the rolling motion complies with § 25.203(c)). *

(v) Normal use of lateral/directional control must produce a roll in the applied direction up to the point where the airplane is considered stalled.

* (vi) In level wing stalls the bank angle may exceed 20 degrees occasionally, provided that lateral control is effective during recovery. *

e. Stall Warning.

(1) Explanation. The purpose of these stall warning requirements is to provide an adequate spread between warning and stall to allow the pilot time to recover without inadvertently stalling the airplane.

(2) Background. To be acceptable, a stall warning must have the following features:

(i) Distinctiveness. The stall warning indication must be clear and distinct to a degree which will ensure positive pilot recognition of an impending stall.

(ii) Timeliness. The stall warning should normally begin at a speed not less than 7 percent above stall speed. A lesser margin may be acceptable depending on the probability of an inadvertent stall following stall warning recognition, and how much difference there is between the speed at which the airplane stalls (stall identification), and the minimum speed allowed under § 25.103(a).

(iii) Consistency. The stall warning must be reliable and repeatable. The warning must occur with flaps and gear in all normally used positions in both straight and turning flight. The warning may be furnished naturally through the inherent aerodynamic characteristics of the airplane, or artificially by a system designed for this purpose. If artificial stall warning is provided for any airplane configuration, it must be provided for all configurations.

(iv) An artificial stall warning indication that is a solely visual device which requires attention in the cockpit, inhibits cockpit conversation, or in the event of malfunction, causes distraction which would interfere with safe operation of the airplane, is not acceptable.

(3) <u>Procedures</u>. Stall warning tests are normally conducted in conjunction with the stall testing required by §§ 25.103 (speeds) and 25.203 (characteristics).

(4) <u>Data Acquisition and Reduction</u>. The stall warning speed and type and quality of warning should be noted. The speed at which acceptable stall warning begins should then be compared to the stall speed as defined in paragraph (3) above to determine if the required margin exists.

g. <u>Accelerated Stall Warning</u>. Determine that adequate stall warning occurs in turning flight under expected conditions of flight for takeoff, enroute, and approach/landing configurations at aft c.g. and heavy weight.

h. <u>Maneuver Margins</u>. Determine that adequate maneuvering capability exists prior to stall warning at V_2, all-engines takeoff speed, final takeoff speed (§ 25.121(c)), and V_{REF} at forward c.g. and heavy weight for each appropriate flap setting.

FIGURE 29-1. STALL TEST TIME HISTORY

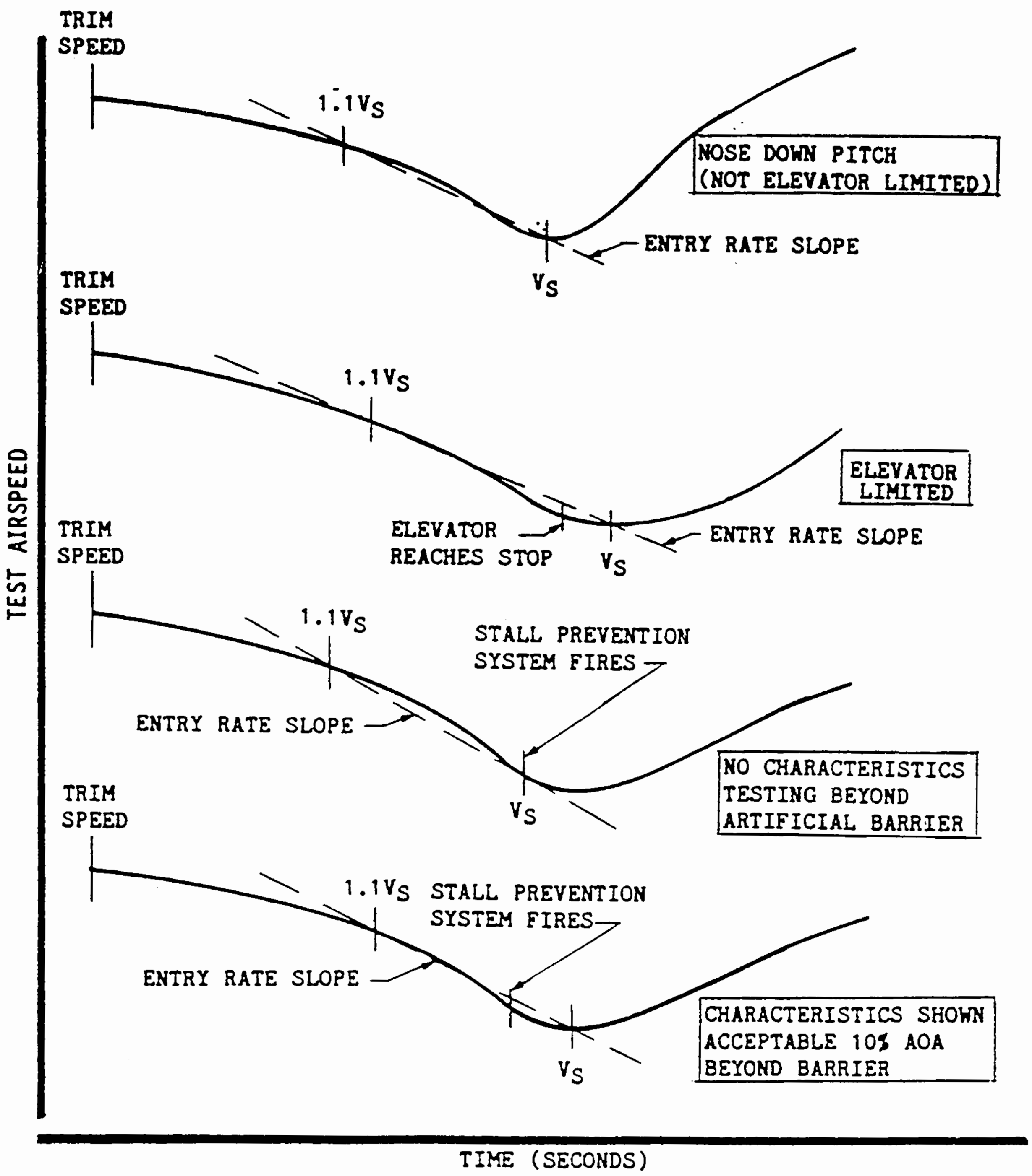


FIGURE 29-2. STALL C_{LCG} VS ENTRY RATE

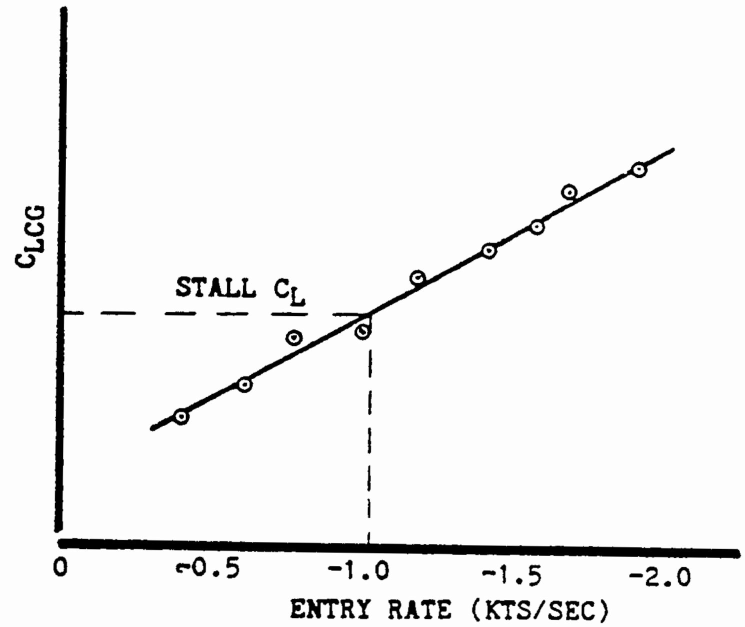


FIGURE 29-3. STALL C_L VS WEIGHT AND FLAP SETTING

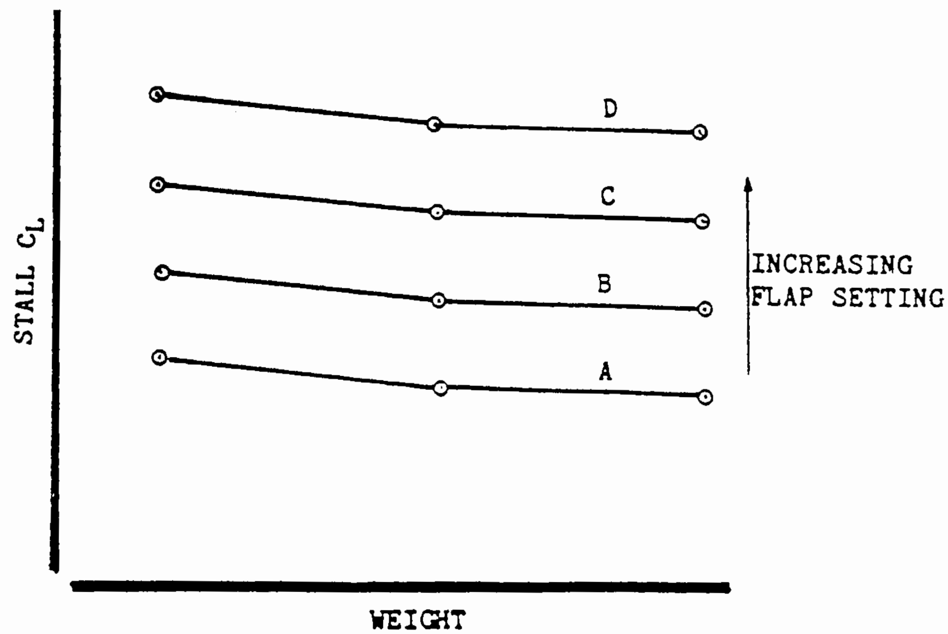


FIGURE 29-4. STALL SPEEDS VS WEIGHT AND FLAP SETTING

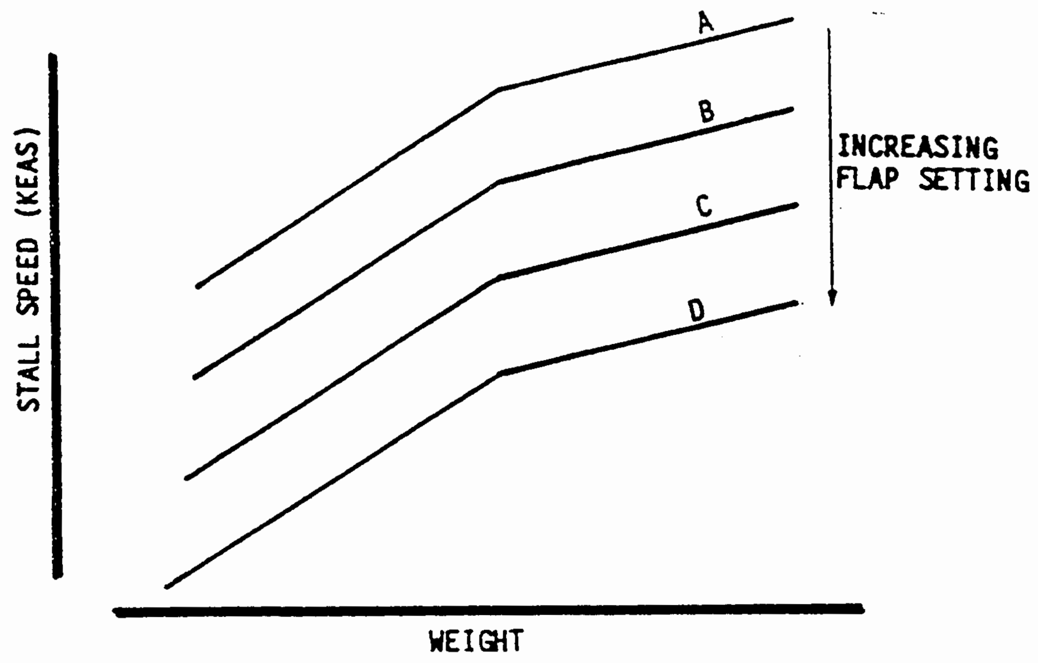
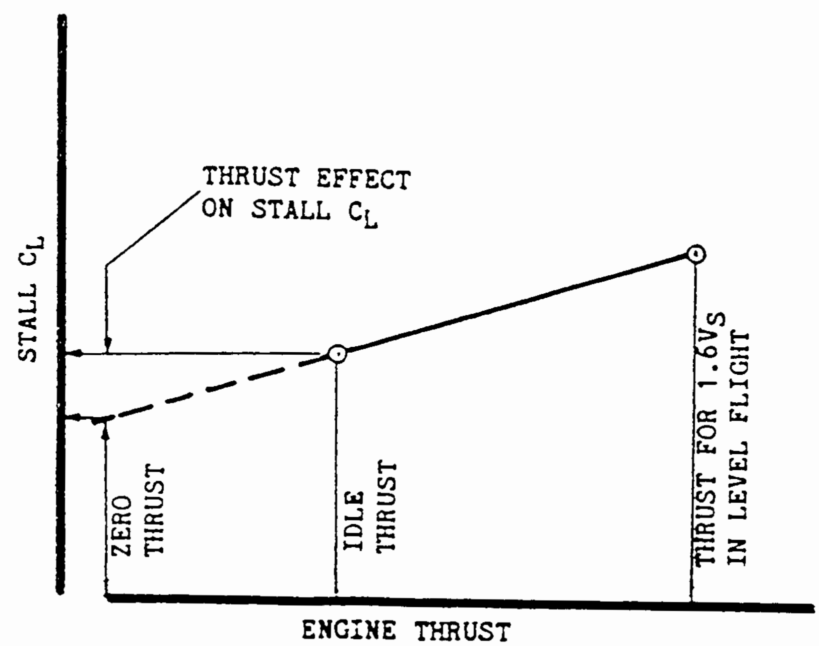


FIGURE 29-5. THRUST EFFECT ON STALL C_L



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